Chapter 6 Shasta Lake Water Resources Investigation

This section describes the feasibility of enlarging Shasta Lake. The information presented in this chapter has been summarized from the Shasta Lake Water Resources Investigation (SLWRI) Plan Formulation Report (PFR) (Reclamation, 2007) (See Box 6-1 for a list of acronyms and abbreviations used in this section). This section also summarizes new information for the SLWRI provided by the Bureau of Reclamation (Reclamation) that reflects recent water management changes, including the 2008 US Fish and Wildlife Service (USFWS) and 2009 National Marine Fisheries Service (NMFS) Biological Opinions (BO), and effects of proposed Sacramento-San Joaquin Delta (Delta) habitat conservation and conveyance actions and climate change.

Study Area and Project Location

Shasta Dam and Lake are on the upper Sacramento River in Northern California (See Figure 6-1). Shasta Dam is located about 9 miles northwest of the city of Redding, and the dam and entire reservoir are in Shasta County. At full pool, Shasta Lake stores 4.55 million acre-feet (MAF), covers an area of about 29,500 acres, and has about 400 miles of shoreline. The reservoir manages runoff from about 6,420 square miles of watershed. Shasta Lake delivers about 55% of the total annual water supply developed by the Central Valley Project (CVP). The Shasta Dam and Lake Project was constructed as an integral part of the CVP. It is operated to provide for the management of flood water; storage of winter runoff for irrigation in the Sacramento and San Joaquin valleys, municipal and industrial (M&I) water supply, maintenance of navigation flows, and protection and conservation of fish in the Sacramento River and Delta; and generation of hydroelectric energy.

The primary study area (Figure 6-1) for the SLWRI is Shasta Dam and Lake; lower reaches of inflowing rivers and streams, including the Sacramento River, McCloud River, Pit River, and Squaw Creek; and the Sacramento River downstream to about the Red Bluff Diversion Dam (RBDD). The RBDD was chosen as the downstream boundary of the primary study area because it is the point at which releases from Shasta Dam begin to have a negligible effect on Sacramento River water temperatures, and the river landscape changes to a broader, alluvial stream system.

Modification of Shasta Dam has of the potential to influence other resource programs and projects in the Central Valley. An extended study area primarily encompasses the following:

- Sacramento River downstream from the RBDD, including parts of the American River basin
- Delta, including parts of the lower San Joaquin River
- Water service areas of the CVP and State Water Project (SWP) that may be affected by changes at Shasta Dam and Lake

Box 6-1. Chapter 6 Acronym and Abbreviation List

AF	acre-feet
BO	Biological Opinion
CALFED	CALFED Bay-Delta Program
CP	comprehensive plan
CVP	Central Valley Project
CVPIA	Central Valley Project Improvement Act
Delta	Sacramento-San Joaquin Delta
^{o}F	degrees Fahrenheit
M&I	municipal and industrial
MAF	million acre-feet
NA	not applicable
NMFS	National Marine Fisheries Service
PFR	Plan Formulation Report
RBDD	Red Bluff Diversion Dam
Reclamation	United States Bureau of Reclamation
RPA	Reasonable and Prudent Alternative
RV	recreational vehicle
SLWRI	Shasta Lake Water Resources Investigation
SWP	State Water Project
TAF	thousand acre-feet
TCD	temperature control device
USFS	United States Forest Service
USFWS	United States Fish and Wildlife Service
WRC	Water Resources Council

Project Objectives

Major water and related resources problems, needs, and opportunities were identified in the primary study area. These include anadromous fish survival, water supply reliability, and other resources needs, as summarized below. The problems and needs serve as the basis for the SLWRI planning objectives. A detailed explanation of the problems, needs, and opportunities for the SLWRI can be found in the SLWRI PFR.

Anadromous Fish Survival

Chinook salmon have declined in the Central Valley due to a number of environmental factors. Key factors affecting Chinook salmon abundance in the Sacramento River is adequate water temperature and flow, especially in dry and critically dry years. Other factors contributing to the decline of this species include loss of historic spawning areas and suitable rearing habitat, water diversions from the Sacramento River, reduction in suitable spawning gravels, fluctuations in river flows, toxic acid mine drainage, unnatural rates of predation, and fish harvests. Various federal, state, and local projects are addressing each of the aforementioned contributing factors. Recovery actions range from changing the timing and magnitude of reservoir releases to changing the temperature of released water. In addition to flow requirements, structural changes have been made at Shasta Dam to change the temperature of released water, such as construction of the temperature control device (TCD), which was completed in 1997. Despite these steps, the need for additional effective actions continues for the Sacramento River, particularly upstream from the RBDD.

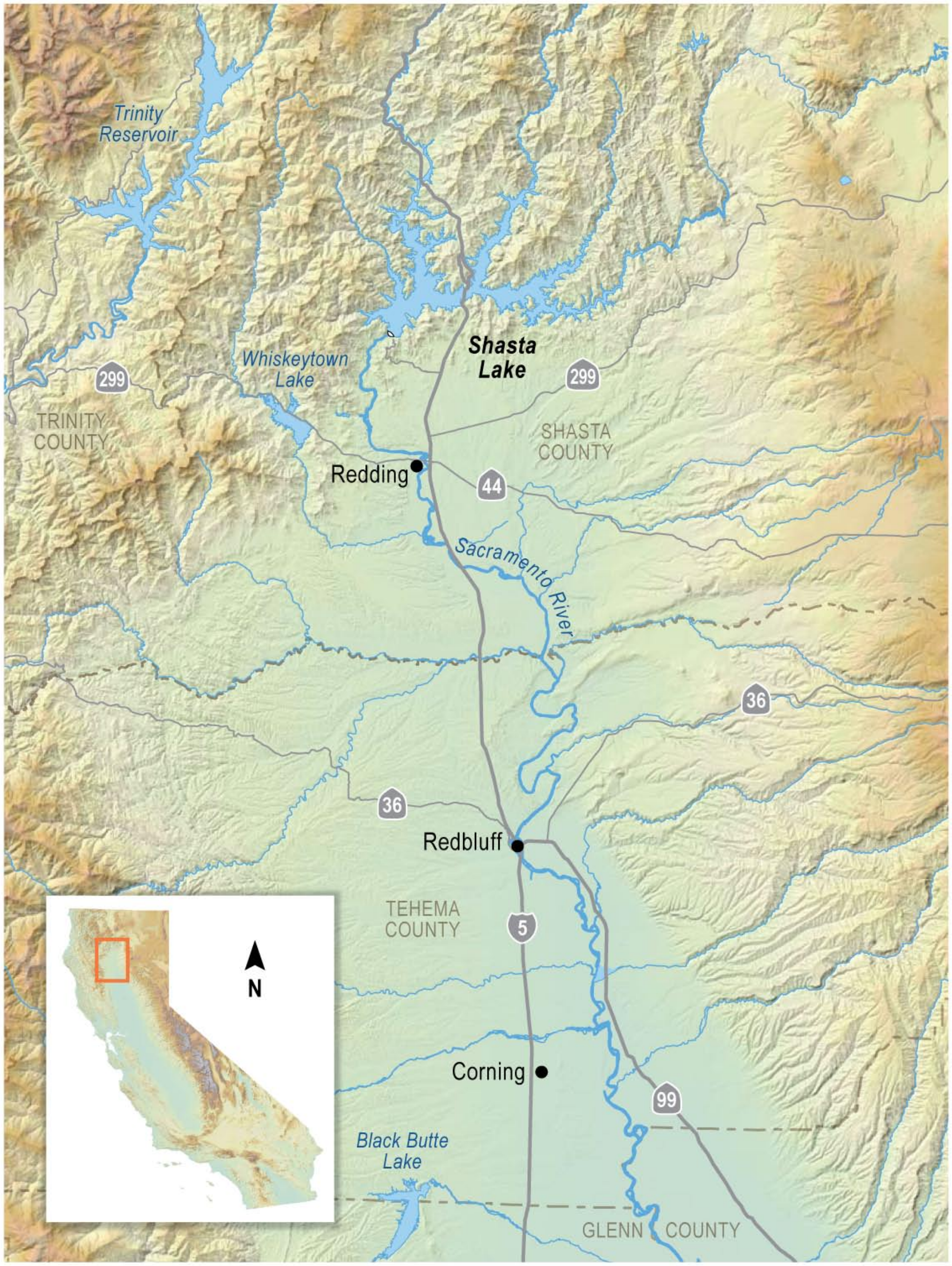

Figure 6-1. Location of Shasta Dam and Lake and SLWRI Primary Study Area

Water Supply Reliability

Demand for water in California exceeds available supplies. As the population of California continues to grow, the demand for adequate water supplies will become more acute. The ability to maintain a healthy and vibrant industrial and agricultural economy will become increasingly difficult. Climate change may result in more variable precipitation, less snowfall, and earlier snowmelt that may exacerbate demands on available water supplies in the future. As owner and operator of the CVP, Reclamation identified the need to increase the reliability of CVP water deliveries to its water contractors for agricultural, M&I, and environmental purposes, particularly during dry and critically dry water years. As one of many efforts to improve the reliability of California's water supply, the SLWRI was established to evaluate the potential to improve water supply reliability primarily by modifying Shasta Dam and enlarging Shasta Lake.

Opportunities

Other identified problems, needs, and opportunities include growing demands for existing and new energy sources in California; the need for restoring environmental values in the Shasta Lake area and downstream along the Sacramento River; the need for additional flood protection along the upper Sacramento River; opportunities for improving water quality conditions downstream of Shasta Dam in the Sacramento River and Delta; and the need to preserve and increase recreation opportunities in the north Sacramento Valley.

Planning Objectives

Two primary and five secondary planning objectives were developed based upon identified water resources problems, needs, and opportunities, and information contained in the CALFED Bay-Delta Program Record of Decision (CALFED, 2000b):

Primary Planning Objectives

- Increase the survival of anadromous fish populations in the Sacramento River, primarily upstream from the RBDD
- Increase water supplies and water supply reliability for agricultural, M&I, and environmental purposes to help meet future water demands, with a focus on enlarging Shasta Dam and Lake

Secondary Planning Objectives

- Preserve and restore ecosystem resources in the Shasta Lake area and along the upper Sacramento River
- Reduce flood damages along the Sacramento River
- Develop additional hydropower capabilities at Shasta Dam
- Preserve and increase recreation opportunities at Shasta Lake
- Preserve and improve water quality conditions in the Sacramento River downstream of Shasta Dam and the Delta

Project Formulation and Initial Alternatives

A No-Action Alternative and five comprehensive plans (CP) were developed based on the above planning objectives.

During alternative formulation, over 60 potential measures were developed based on information from previous studies, programs, and projects to address the primary and secondary planning objectives and satisfy the other planning constraints, considerations, and criteria. These measures were reviewed and other measures were developed during study team meetings, field inspections, environmental scoping, and outreach for the SLWRI. Measures that were believed to best address the objectives of the SLWRI were retained and combined into initial plans believed to represent the range of potential alternatives that best addressed the planning objectives.

Based on initial plans, structural alternatives were formulated focusing on different dam raise heights within the range of 6.5 to 18.5 feet. Although higher dam raises are technically and physically feasible, 18.5 feet is the largest dam raise that would not require extensive and very costly reservoir area relocations, such as moving the Pit River Bridge, I-5, and the Union Pacific Railroad. While any dam raise options up to 18.5 feet are possible, three dam raises—6.5-feet, 12.5-feet, and 18.5-feet—adequately represent the extent of benefits, impacts, and costs associated with any raise within the 6.5-foot to 18.5-foot range.

The next step in developing the alternatives was to formulate comprehensive plans focusing on anadromous fish survival, water supply reliability, and the other objectives. The CPs were formulated to represent a comprehensive and reasonable balance between the two primary objectives, while also including components to address the secondary objectives, as appropriate. The following CPs are under consideration:

- **Comprehensive Plan 1 (CP1) – 6.5-Foot Dam Raise, Anadromous Fish Survival and Water Supply Reliability** – CP1 focuses on increasing water supply reliability and improving anadromous fish survival with benefits to other resources through a 6.5-foot raise of Shasta Dam and 256,000 acre-feet (AF) enlargement of Shasta Lake.
- **Comprehensive Plan 2 (CP2) – 12.5-Foot Dam Raise, Anadromous Fish Survival and Water Supply Reliability** – As with CP1, this CP focuses on increasing water supply reliability and improving anadromous fish survival with benefits to other resources through a 12.5-foot raise of Shasta Dam and 443,000 AF enlargement of Shasta Lake. A dam raise of 12.5-feet represents a midpoint between the likely smallest dam raise considered (6.5-foot dam raise) and the largest practical dam raise (18.5-foot dam raise).
- **Comprehensive Plan 3 (CP3) – 18.5-Foot Dam Raise, Anadromous Fish Survival and Water Supply Reliability** – CP3 was formulated as the greatest practical enlargement of Shasta Dam and Lake and focuses on increasing water supply reliability and improving anadromous fish survival with benefits to other resources through an 18.5-foot raise of Shasta Dam and 634,000 AF enlargement of Shasta Lake.
- **Comprehensive Plan 4 (CP4) – 18.5-Foot Dam Raise, Anadromous Fish Focus** – Similar to CP3, CP4 was formulated the greatest practical enlargement of Shasta Dam and Lake (18.5-foot raise of Shasta Dam); however, CP4 focuses on improving anadromous fish survival with some benefits to water supply reliability and other resources. Of the 634,000 AF of increased storage space, close to 60% (378,000 AF) would be dedicated to increasing the cold-water supply for anadromous fish purposes.
- **Comprehensive Plan 5 (CP5) – 18.5-Foot Dam Raise, Combination Plan** – CP5 is a combined plan similar to CP3 that also includes features for ecosystem restoration and additional recreation facilities around Shasta Lake. Formulation of specific environmental restoration features and increased recreation components is not yet complete but will be included in the draft Feasibility Report.

Each of the CPs were evaluated against the specified planning objectives and four criteria of completeness, effectiveness, efficiency, and acceptability, as identified in the federal planning guide *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* (WRC, 1983). It was found that at this stage of SLWRI planning, each CP ranked similarly. All of the plans were found to meet the completeness criterion. All of the plans would accomplish the planning objectives as formulated, and are economically feasible. Each of the CPs is estimated to be complete, appears to be effective in achieving its intended objectives, and is economically feasible. All plans would be cost effective under future conditions when the reliability of sufficient supplies of water diminishes. All plans are estimated to meet the acceptability criteria, although continued coordination of the plans is necessary among other agencies and public interests.

All of the CPs would increase water supply reliability by increasing firm water supplies for irrigation and M&I purposes primarily during drought periods. In addition, each CP would increase the ability of Shasta Dam to meet target flow requirements, make cold-water releases and regulate water temperature in the upper Sacramento River, primarily in dry and critically dry years. All of the CPs include features to maintain the existing recreation capacity at Shasta Lake and would provide for modernized recreation facilities. Increasing the size of Shasta Dam and Reservoir would also result in the ability to increase hydropower generation at Shasta Dam generating facilities, and would provide incidental flood protection benefits along the Sacramento River.

Example 18.5-Foot Shasta Dam Raise Project Formulation Project Features and Costs

This section describes an example 18.5-foot Shasta Dam raise project formulation that focuses on a broad range of benefits. The example project formulation is most similar to CP5 from the PFR. Facilities and costs are generally the same as presented in the PFR; however, operations have been modified to account for new regulations in the Sacramento River and the Delta.

Example 18.5-Foot Shasta Dam Raise Project Formulation Project Features

The example 18.5-foot Shasta Dam raise project formulation would address both the primary and secondary planning objectives. The example project formulation focuses on increased water supply reliability and improving anadromous fish survival, while also enhancing Shasta Lake area and upper Sacramento River environmental resources, and providing increased recreation opportunities (formulation of specific environmental restoration features and increased recreation components is not yet complete but will be included in the draft Feasibility Report). The additional storage created by the 18.5-foot dam raise would be used to increase water supply reliability and improve the ability to meet temperature and flow objectives for anadromous fish. The capacity of the reservoir would increase by 634,000 AF to a total of 5.19 MAF and the existing TCD would be extended to achieve efficient use of the expanded reservoir. Table 6-1 summarizes the physical features associated with an 18.5 foot dam raise. Figure 6-2 illustrates the inundation area of an enlarged Shasta Lake and major project features.

Table 6-1. Summary of the Example 18.5-foot Shasta Dam Raise Project Features

Project Feature	Details
Dam and Appurtenant Structures	
Main Dam	Remove existing structures on Dam Crest Raise Dam Crest 18.5-feet using mass concrete and structural concrete placements New dam crest will have same surface area and similar features as existing dame crest
Full Pool Height Increase (feet)	20.5
Elevation of Full Pool (feet)	1,087.50
Capacity Increase (AF)	634,000
Wing Dams	Left wing-dam raised 18.5 feet Extend reinforced-concrete core wall to meet dam crest Rock-fill placed downstream from core wall Construct new upstream parapet wall for flood protection Replace gantry crane
Spillway	Raise crest Raise and extend piers downstream to support new spillway bridge Replace 3 drum gates with 6 sloping wheel gates
Spillway Crest Elevation (feet)	1,060
Temperature Control Device	Raise/modify controls
Pit 7 Dam	Minor modifications to the powerhouse
Reservoir Area Dikes and Railroad Embankments	Construct 7 new dikes
Relocations	
Roadways	Modify or relocate 30 road segments, approximately 6 miles total
Vehicle Bridges	Relocate 4 bridges Modify 1 bridge
Railroad Bridges	Modify 3 bridges
Recreation Facilities	Modify or replace portions of existing recreation facilities around Shasta Lake including, marinas, boat ramps, resorts, campgrounds/day use areas/RV sites, USFS facilities, and trails
Utilities	Relocate inundated utilities Construct wastewater treatment facilities
Ecosystem Restoration	Construct shoreline fish habitat around Shasta Lake Augment spawning gravel in the upper Sacramento River Restore riparian habitat and floodplain in the upper Sacramento River Enhance aquatic habitat in tributaries to Shasta Lake to improve fish passage

AF = acre-feet

RV = recreational vehicle

USFS = United States Forest Service

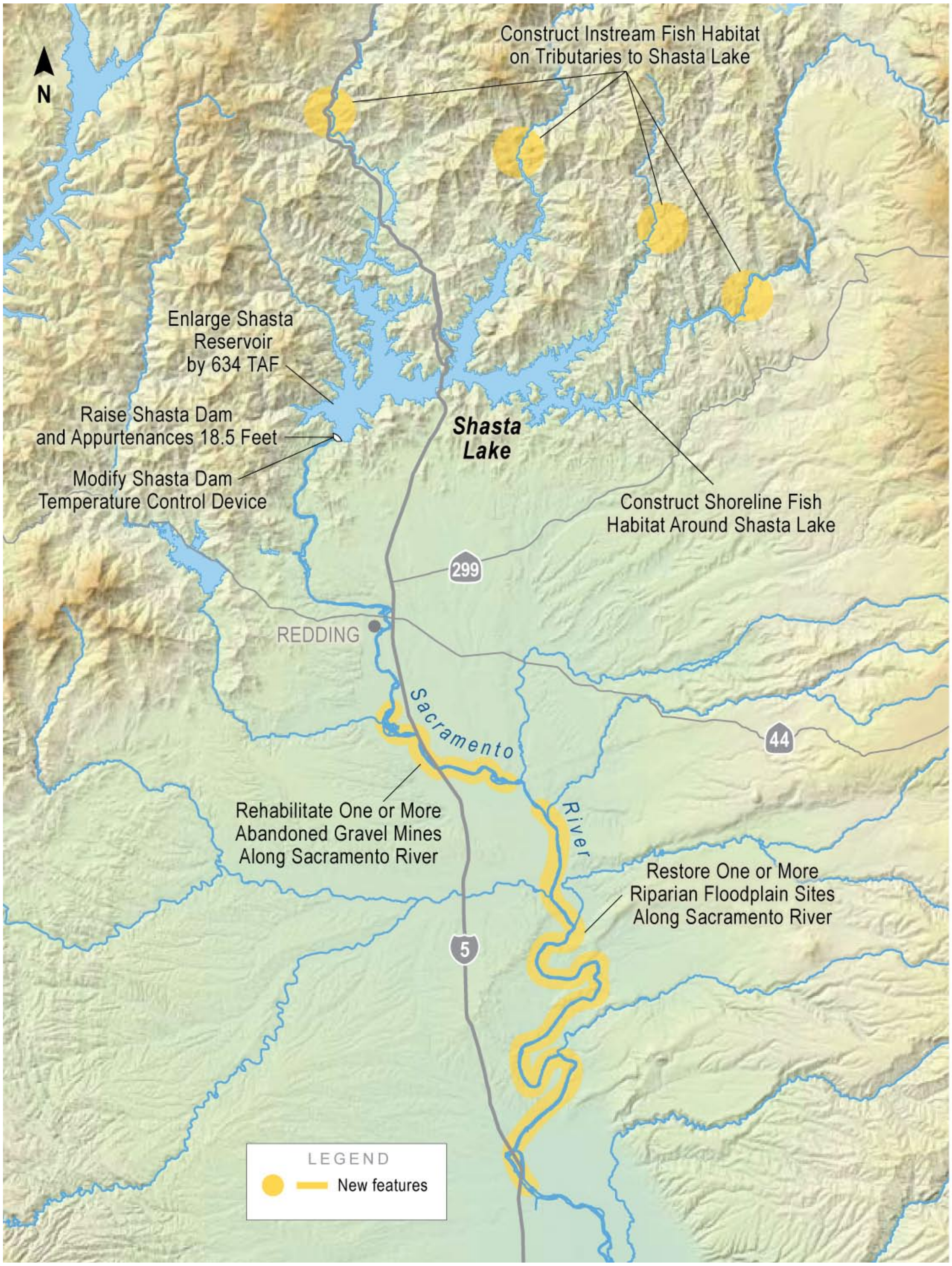

Figure 6-2. 18.5-foot Shasta Dam Raise Project Features

As indicated in Table 6-1, the example project would include measures to address ecosystem restoration and enhanced recreation in the Shasta Lake area. Ecosystem restoration features under development for the example project include (1) restoring resident fish habitat in Shasta Lake, (2) restoring fisheries and riparian habitat at several locations along the lower reaches of the upper Sacramento River and other tributaries to Shasta Lake, (3) augmenting spawning gravel in the Sacramento River, and (4) restoring riparian and floodplain habitat in the Sacramento River. The example project would also include features to avoid and offset adverse effects to existing recreation facilities at Shasta Lake, as well as construct additional facilities for recreation within the vicinity of Shasta Lake. Restoration and recreation features are still under development and will not be fully identified until the draft Feasibility Report.

Example 18.5-Foot Shasta Dam Raise Project Formulation Project Costs

The estimated capital cost for an example 18.5-foot Shasta Dam raise project formulation is $942 million (presented in October 2006 dollars). Project cost estimates are based on appraisal-level engineering studies for the various facilities and are subject to change as the feasibility study progresses.

Example 18.5-Foot Shasta Dam Raise Project Formulation Operations

Major operational priorities of this example project formulation are to improve the survivability of anadromous fish by providing increased coldwater supplies and improve the reliability of water supply to water contractors and environmental purposes. Under the example plan, the enlarged Shasta Dam can be operated in a variety of ways. The increase in cold-water pool resulting from an 18.5-foot raise of Shasta Dam would allow Shasta Reservoir operations to provide not only a more reliable source of water during critical and dry water years, but also provide more cool water for release into the Sacramento River for anadromous salmonids, as water temperatures that are too high can be detrimental to the various life stages of salmon. Elevated water temperatures can negatively impact spawning adults, egg maturation and viability, and preemergent fry, significantly diminishing the resulting ocean population and next generation of returning spawners.

The enlarged dam and reservoir would be operated for water supply to the CVP and SWP under existing operational guidelines. Temperature operations would be controlled by extending the existing TCD for efficient use of the expanded coldwater pool. Water operations modeling performed for this report was based primarily on existing and future operational constraints. Unlike previous modeling conducted under the SLWRI, water operations modeling for this report included CVP and SWP operational conditions described in the 2008/2009 BOs, which included reasonable and prudent alternatives (RPA) that impact water management operations at Shasta Dam.

The goal of the RPAs recommended by NMFS is to manage water temperatures in the upper Sacramento River to protect Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, Central Valley steelhead, and Southern distinct population segment of the North American green sturgeon. Actions are focused on reducing the risk of temperature effects to egg incubation in the upper river, especially to winter-run and spring-run spawning below Shasta Dam. The RPAs include a new year-round storage and temperature management program for the upper Sacramento River, particularly release schedules for Keswick Dam/Shasta Dam, and procedures based on end-of-September storage targets for Shasta Lake.

Example 18.5-Foot Shasta Dam Raise Project Formulation Benefits

This section presents new modeling conducted for an example formulation of an 18.5-foot Shasta Dam Raise that includes new operating criteria recommended by the NMFS and USFW BOs and summarizes potential project benefits. This section describes how the example 18.5-foot Shasta Dam raise project formulation would meet primary objectives and achieve project benefits, including public benefits. This presentation distinguishes between public and non-public benefits based on guidance from the 2009 Comprehensive Water Package. According to the 2009 Water Package, public benefits may include ecosystem improvements, water quality improvements, flood control benefits, emergency response, and recreation. Water supply reliability and water quality benefits for M&I and agricultural users and hydropower generation are assumed to be non-public benefits.

The information presented in this section is for informational purposes only. The example project formulation presented in this section was formulated to fulfill a wide variety of project benefits and may not represent the most technically and/or economically feasible alternative considered in past and/or future feasibility study reports and environmental documentation, and should not be considered as a preferred alternative.

Potential benefits are illustrated in Figure 6-3.

Public Benefits

The example 18.5-foot Shasta Dam raise project formulation could provide public benefits, including ecosystem improvements, water quality improvements, flood control benefits, and recreation, as described in the following sections.

Ecosystem Improvements

The additional storage created by the 18.5-foot dam raise would be used to improve the ability to meet temperature and flow objectives for anadromous fish. The example project formulation could increase the ability of Shasta Dam to make cold-water releases and regulate water temperatures in the upper Sacramento River, and increase the ability to meet target flow requirements for anadromous fish, primarily in dry and critically dry years.

Cold water released from Shasta Dam significantly influences water temperature conditions on the Sacramento River between Keswick and Red Bluff. Raising Shasta Dam would increase the depth of the cold-water pool in Shasta Lake, resulting in an increase in seasonal cold-water volume below the thermocline (layer of greatest water temperatures and density change). Table 6-2 provides recent modeling results illustrating how the example 18.5-foot Shasta Dam Raise project formulation can provide temperature benefits to the Sacramento River and increase coldwater pool in Shasta Lake.

Raising Shasta Dam could contribute to anadromous fish survival by increasing Reclamation’s ability to maintain suitable water temperatures in the Sacramento River and meet other legal and institutional requirements for instream flows and other water quality parameters. Increased Shasta storage could contribute to additional flow releases in the Sacramento River during critical periods for fish species.

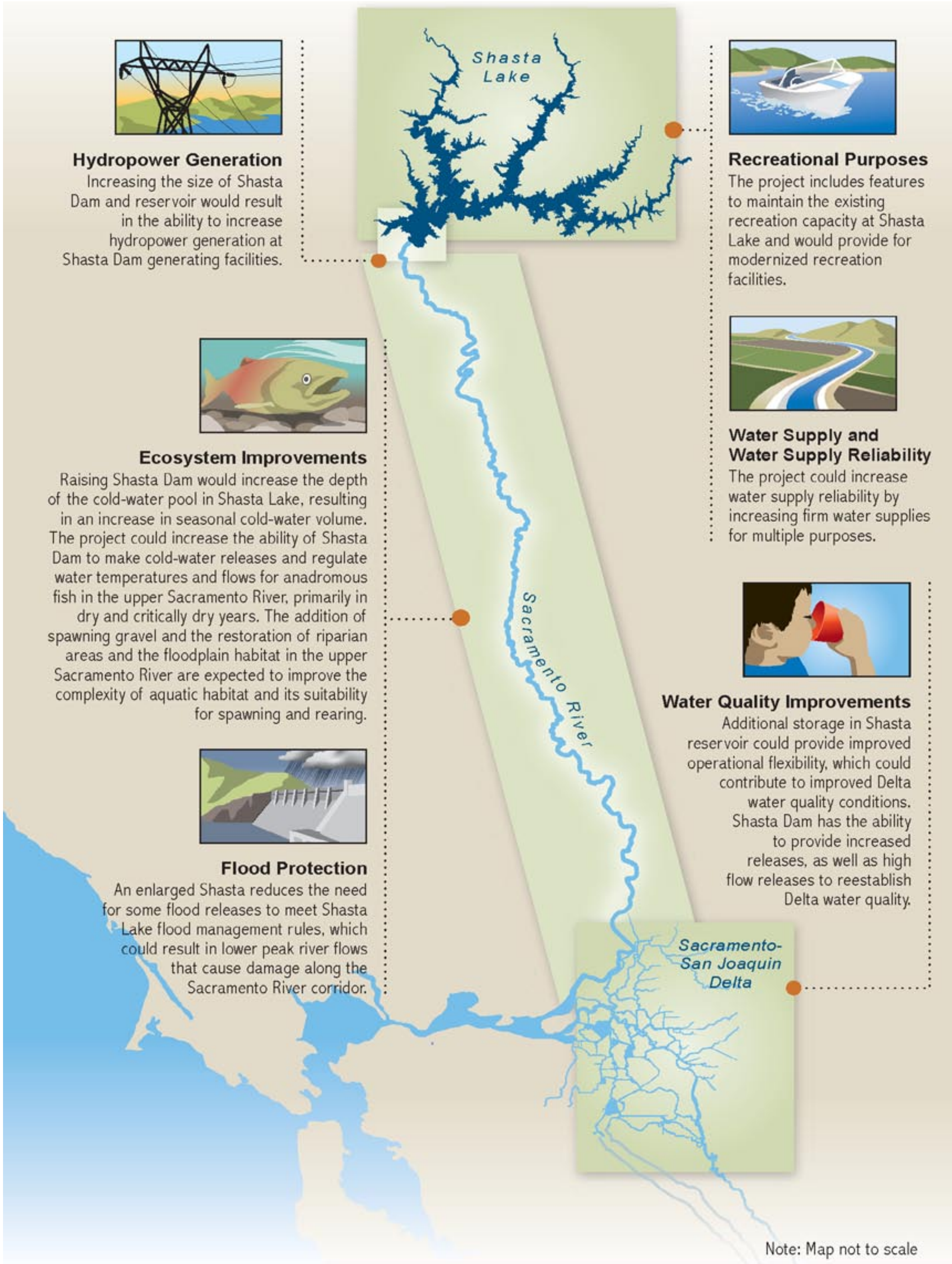

Figure 6-3. Summary of Potential Benefits of the Example 18.5-foot Shasta Dam Raise Project

Table 6-2. Potential Anadromous Fish and Ecosystem Restoration Benefits of the Example 18.5-foot Shasta Dam Raise Project Formulation

Potential Anadromous or Ecosystem Restoration Action/Target	Long-Term Average[1]	Driest Periods Average[2]
Change in Sacramento River Peak June-October Temperature at Balls Ferry (°F)	-0.61	-0.43
Change in Sacramento River Average June-October Temperature at Balls Ferry (°F)	-0.92	-0.64
Change in Sacramento River Peak June-October Temperature at Bend Bridge (°F)	-0.48	-0.44
Change in Sacramento River Average June-October Temperature at Bend Bridge (°F)	-1.37	-1.09
% of years meeting or exceeding the Balls Ferry Peak Temperature target of < 56°F (% improvement)	80 (+22)	NA
% of years with Shasta Lake End of September Storage greater than 2.2 MAF (% improvement)	84 (+4)	NA
% of years with Shasta Lake End of September Storage greater than 2.2 MAF with following End of April Storage Condition greater than 3.8 MAF (% improvement)	74 (+9)	NA
% of years with Shasta Lake End of September Storage greater than 3.2 MAF (% improvement)	57 (+35)	NA

°F = degrees Fahrenheit

MAF = million acre-feet

NA = not applicable

Notes: [1] Long-term average is the average for the period October 1922 to September 2003.

[2] Driest periods average is the average for the combinations of periods May 1928 to October 1934, October 1975 to September 1977, and June 1986 to September 1992.

Enlargement of Shasta Dam and Lake can also contribute to ecosystem restoration along the Sacramento River and in the Delta. Improvements to both water temperature and flows for Sacramento River aquatic species could be accomplished. In the upper Sacramento River, the addition of spawning gravel and the restoration of riparian areas and floodplain habitat are expected to improve the complexity of aquatic habitat and its suitability for spawning and rearing. Riparian areas provide habitat for a diverse array of plant and animal communities along the Sacramento River, including numerous threatened or endangered species. Riparian areas also provide shade and woody debris that increase the complexity of aquatic habitat and its suitability for spawning and rearing. Lower floodplain areas, river terraces, and gravel bars play an important role in the health and succession of riparian habitat.

In addition to the aforementioned ecosystem benefits, the example project formulation also includes benefits to ecosystem restoration around Shasta Lake. Ecosystem restoration around Shasta Lake includes improving shallow, warm-water habitat by installing artificial fish cover, such as anchored complex woody structures and boulders, and planting water-tolerant and/or erosion-resistant vegetation near the mouths of tributaries. The placement of manzanita brush structures near the Shasta Lake shoreline would enhance the diversity of structural habitat available for the warm-water fish species that occupy Shasta Lake. These improvements would help provide favorable spawning conditions, and juvenile fish leaving the tributaries would benefit from improved adjacent shoreline habitat. The lower reaches of perennial tributaries to Shasta Lake would be targeted for aquatic restoration because they provide year-round fish habitat. Native fish species require connectivity to the full range of habitats offered by Shasta Lake and its tributaries. Improved fish passage addresses the requirement to provide the access and/or barriers necessary for ecological conditions that support these native fish assemblages.

Water Quality Improvements

Additional storage in Shasta Reservoir would provide improved operational flexibility, which could contribute to improved Delta water quality conditions and Delta emergency response. Shasta Dam has the ability to provide increased releases, as well as, high flow releases to reestablish Delta water quality. Improved Delta water quality conditions could provide benefits for both water supply reliability and ecosystem restoration by potentially increasing Delta outflow during drought years, and reducing salinity during critical periods.

Flood Control Benefits/Flood Protection

The example project formulation would provide incidental flood protection benefits along the Sacramento River. Enlarging Shasta Dam and Reservoir could provide greater flexibility in flood control releases in the CVP/SWP system due to the potential for additional flood control space within Shasta Reservoir. A reduction in the need for releases to meet flood management rules in Shasta Lake could result in lower peak river flows that cause damage along the river corridor. While planning analysis on a monthly time step may not capture the operations in reaction to flood events, information suggests that flood management releases can be reduced by an average of 70 thousand acre-feet (TAF) per year, resulting in the potential reduction of flood damage and allowing the water supply to be conserved for subsequent use.

Recreational Purposes

The example project formulation includes features to maintain the existing recreation capacity at Shasta Lake and would provide for modernized recreation facilities and an enlarged lake surface area for water-based recreation in nearly all year types. Shasta Lake is one of the most visited recreation destinations in the state and region, given its large size, favorable climate, and easy access. Additional flexibility in managing the resource for recreation is an anticipated benefit of increased storage capacity.

Water Supply Reliability Benefits

The example project formulation could increase water supply reliability by increasing firm water supplies for irrigation and M&I purposes primarily during drought periods. This water supply increase could contribute to replacement of supplies redirected to other purposes in the Central Valley Project Improvement Act (CVPIA). Since the enactment of the CVPIA, 1.2 MAF of CVP yield have been dedicated and managed annually for the primary purpose of implementing the fish, wildlife, and habitat restoration purposes and measures authorized by the CVPIA.

The example project formulation would help reduce estimated future shortages by increasing the reliability of firm water supplies in dry periods by at least 71 TAF per year, and average annual yield by about 74 TAF per year.

Hydropower Generation

Increasing the size of Shasta Dam and Lake would result in higher water surface elevations in the reservoir, which would result in a net increase in the power generation at Shasta Dam facilities. Also, additional flows captured by the enlarged reservoir would pass through the hydropower generation facilities at both Shasta Dam and Keswick Dam. Updated analysis shows the capacity to increase power production by an average of 3.2% in dry years and by 2.6% overall. The net generation of the example project is positive and beneficial. Net generation accounts for both increased generation at Shasta Dam due to an enlarged reservoir and additional energy requirements required for pumping the increased water supplies to contractors.

Example 18.5-Foot Shasta Dam Raise Project Formulation Benefits Under an Uncertain Future

As stated previously in this report, future conditions are uncertain at this time and considered projects must be able to fulfill project objectives and provide benefits under variable future conditions. This section describes new modeling conducted for this report and presents new information on how an example enlarged Shasta Lake could be coordinated with potential new Delta conveyance. The section also presents a qualitative discussion of the potential impacts of climate change on project benefits. The information presented in this section is for informational purposes only. As stated previously, the example project formulation presented in this section was formulated to fulfill a wide variety of project benefits and may not represent the most technically and/or economically feasible alternative considered in past and/or future feasibility study reports and environmental documentation, and should not be considered as a preferred alternative.

Potential Effect of New Delta Conveyance on Project Benefits

This section presents how an example 18.5-foot Shasta Dam raise project could accomplish project objectives and provide benefits under future operation scenarios that include potential new Delta conveyance, as being studied by the Bay-Delta Conservation Plan and Delta Habitat Conservation and Conveyance Program. This section focuses on qualitative analysis conducted for ecosystem improvements, water supply reliability, and hydropower generation. Other benefit categories discussed above are not expected to change significantly with new Delta conveyance; however, further analysis will be conducted as the feasibility study progresses.

Ecosystem Improvements

As with the example project formulation without new Delta conveyance, raising Shasta Dam would increase the depth of the cold-water pool in Shasta Lake and result in an increase in seasonal cold-water volume. The example project formulation with or without new conveyance could increase the ability of Shasta Dam to make cold-water releases and regulate water temperatures in the upper Sacramento River, and increase the ability to meet target flow requirement for anadromous fish, primarily in dry and critically dry years.

Table 6-3 provides recent modeling results illustrating how the example 18.5-foot Shasta Dam Raise project formulation under an operation that includes new Delta conveyance can provide temperature benefits to the Sacramento River and increase coldwater pool in Shasta Lake.

The success of the RPAs described in the 2008 USFWS and 2009 NMFS BOs depends on Reclamation’s ability to store enough water in Shasta Reservoir to develop a suitable cold-water pool volume to provide suitable water temperatures in the Sacramento River. In addition, tradeoffs exist between the use of new conveyance to address water supply reliability issues and the use of increased storage capacity to improve cold water pool and address temperature compliance performance measures. As with the example project formulation without new Delta conveyance the example project formulation provides additional ecosystem benefits in the upper Sacramento River and around Shasta Lake.

Table 6-3. Potential Anadromous Fish and Ecosystem Restoration Benefits of the Example 18.5-foot Shasta Dam Raise Project Formulation with New Delta Conveyance

Potential Anadromous or Ecosystem Restoration Action/Target	Long-Term Average[1]	Driest Periods Average[2]
Change in Sacramento River Peak June-October Temperature at Balls Ferry (°F)	-0.49	-0.51
Change in Sacramento River Average June-October Temperature at Balls Ferry (°F)	-0.41	-0.28
Change in Sacramento River Peak June-October Temperature at Bend Bridge (°F)	-0.39	-0.53
Change in Sacramento River Average June-October Temperature at Bend Bridge (°F)	-0.28	-0.26
% of years meeting or exceeding the Balls Ferry Peak Temperature target of < 56°F (% improvement)	57 (+18)	NA
% of years with Shasta Lake End of September Storage greater than 2.2 MAF (% improvement)	87 (+4)	NA
% of years with Shasta Lake End of September Storage greater than 2.2 MAF with following End of April Storage Condition greater than 3.8 MAF (% improvement)	73 (+5)	NA
% of years with Shasta Lake End of September Storage greater than 3.2 MAF (% improvement)	56 (+22)	NA

°F = degrees Fahrenheit
MAF = million acre-feet
NA = not applicable
Notes: [1] Long-term average is the average for the period October 1922 to September 2003.
[2] Driest periods average is the average for the combinations of periods May 1928 to October 1934, October 1975 to September 1977, and June 1986 to September 1992.

Water Supply Reliability Benefits

With new Delta conveyance, the example project formulation would help reduce estimated future shortages by increasing the reliability of firm water supplies in dry periods by at least 70 TAF per year, and average annual yield by about 85 TAF per year. Enlarged Shasta Lake conservation storage capacity allows the increased flexibility afforded by new Delta conveyance to be used to greater advantage in meeting water supply reliability goals. As with the existing Delta conveyance option, the benefit is achieved through the improved ability to capture and conserve inflows in wetter periods for use in prolonged dry periods.

Hydropower Generation

As with the existing Delta conveyance option, increasing the size of Shasta Dam and Lake would result in the ability to increase hydropower generation at Shasta Dam facilities. Additional releases of water for delivery benefits can be passed through the power plant, and analysis shows an overall capacity to increase power production by 2.5%.

Potential Effect of Climate Change on Project Benefits

Potential effects of climate change may include higher temperatures, less snowfall, earlier snowmelt, changes to precipitation amounts and timing, and changes to demands on available water supplies. It is unlikely that changes in snow levels would affect Shasta Reservoir as significantly as other Central Valley reservoirs because Shasta Reservoir is primarily filled by direct rainfall runoff, as opposed to snowmelt. Changes to the quantity and timing of rainfall are anticipated to have a greater effect on managing Shasta Lake operations under changing climate scenarios. The SLWRI has recommended further investigations into the identification of climate change effects on the CPs, including suggestions for applying watershed-scale hydrologic models that can provide more information on hydrologic consequences of precipitation changes.

Increased reservoir capacity has the potential to improve flexibility in managing water resources under the level of uncertainty created by climate change, particularly in reacting to impacts of precipitation amounts, timing, and intensity. This improved flexibility could be seen in several elements of targeted benefits. Changes in water management operations downstream and in the Delta could affect Shasta Reservoir operations. If precipitation increases, it may further enhance the benefits of increased reservoir capacity. The challenge of maintaining the balance between an adequate cold water pool and instream flow requirements in dry years will be greater under future conditions which are likely to include warming temperatures. Increased storage is anticipated to help provide better cold water conditions and increased flexibility in meeting flow requirements. Increased generation of hydropower as a result of enlarged storage capacity of Shasta Lake is recognized as a benefit in replacing other forms of energy generation that contribute to greenhouse gas emissions. Water supply reliability benefits of additional storage will be important to providing responses to changes in agricultural and municipal demands by water users.

Shasta Reservoir Enlargement Potential Environmental Effects

A draft Feasibility Report and Environmental Impact Statement disclosing environmental impacts resulting from the SLWRI is scheduled for public release in 2011. Environmental studies and evaluations are being conducted to determine the type and extent of potential environmental impacts anticipated.

All five CPs are expected to be similar in terms of their potential environmental effects. As mentioned above, the changes in temperature and flows are expected to have a beneficial impact on anadromous fish resources. Potential impacts on flow and stages of the upper Sacramento River from this plan are expected to be minimal. During most years, annual operations of Shasta Reservoir, and subsequent flows and stages in the Sacramento River, would be relatively unchanged. All potential noticeable changes in flows and stages would diminish rapidly downstream from RBDD.

It is anticipated that some of the adverse effects of the CPs would be temporary. The primary long-term impacts of the example project in the Shasta Lake area would be due to the increased water surface elevations and inundation area. General types of impacts include potential inundation of terrestrial and aquatic habitat, buildings, sections of paved and nonpaved roads, recreation facilities, and low-lying bridges. The scale of some adverse effects related to expanded construction areas associated with increased reservoir area is likely to be exacerbated by larger dam raises.

As part of the project planning and environmental assessment process, Reclamation will incorporate environmental commitments and best management practices to avoid or minimize potential effects. Reclamation has also committed to coordinate with applicable resource agencies during planning, engineering, design, construction, operation, and maintenance phases of the project. Reclamation will continue to coordinate with the State and potential non-federal sponsors to develop strategies to address potential impacts on the McCloud River (a reach protected by the state Wild and Scenic River Act) and with tribal groups on potential impacts to sites valued for historic and cultural significance.